INTRAOPERATIVE MONITORING OF TEMPERATURE DISTRIBUTION DURING CEMENTED BIRMINGHAM HIP RESURFACING

INTRODUCTION
Concerns related to the exothermic reaction during cement polymerisation have long been questioned in cemented arthroplasty [1]. Potential adverse reactions to cement related to residual monomer and thermal necrosis due to excessive heat is a complex problem with many variables (chemistry, technique, amount etc). Thermal necrosis has been reported when bone is exposed to 50°C for than 1 minute [2]. This study examined the temperature distribution in the femoral head during cemented Birmingham hip resurfacing.

METHODS
Ethics approval was obtained to examine the temperature distribution during cemented hip resurfacing in patients scheduled for a total hip replacement. Six patients were examined in this study. The femoral head was prepared for a resurfacing prosthesis (Birmingham Hip) using the appropriate surgical technique and instrumentation. Type K thermocouples (0.5 mm) with 1.5 m leads were sterilized inserted into the femoral head cancellous bone at fixed sites prior to prosthesis cementing. The implants were cemented using Simplex with antibiotics mixed in an open bowl fashion for 3 minutes prior to cementing. Baseline temperature readings of the thermocouples in the bone as well as room temperature were performed. The temperature of the 6 thermocouples in the bone and a thermocouple placed directly into the excess cement in the mixing bowl was monitored for 20 minutes using a datalogger at 2Hz. The heads were resected and the total hip replacement completed. The heads were fixed in formalin and sectioned using a Buehler Isomet 5000 to examine thermocouple position and cement mantle. Sections were x-rayed using a Faxitron with mammography film.

RESULTS
Mean temperature in the femoral head prior to cementation was 25 °C. No rise in temperature was noted for approximately 10 minutes following cementing and placement of the prosthesis. An increase in temperature occurred thereafter in some of the thermocouples in the femoral head and the thermocouple in the cement in the mixing bowl. The cement in the mixing bowl reached a maximum temperature of 110.2°C whereas the maximum temperature recorded within the femoral head for all 6 patients was 54.1 °C. The average increase in temperature over the 20-minute monitoring period was 9.8°C in the cancellous bone in the femoral head. Peak temperatures occurred in all cases between 11 and 12 minutes following initial cement mixing and required approximately 3 minutes to stabilize back to body temperature. Figure 2 presents a typical temperature profile for 1 thermocouple in the bone and in the mixing bowl.

Sectioning analysis revealed cement penetration was not uniform around the circumference of the implant and a full circumferential cement mantle was not always achieved. Cement penetration was significantly greater at the superior aspect of the head (P<0.02) and decreased inferiorly. The thermocouples found within the cement mantle were those that increased in temperature in this study. Similarly, the thermocouples where no cement was found or not adjacent to cement did not increase to any great extent.

DISCUSSION
Bone cement polymerization is an exothermic reaction and produces excessive amounts of heat in vitro. The magnitude of temperature changes at the bone-cement interface reported from in vivo and in vitro studies however differs. Wykman [3] reported a median temperature of 49 °C at the cement-bone interface in vivo in the acetabulum during cementing. Larsen and Ryd [4] reported the temperature at the cement-bone interface to be 37 °C (range 31-50°C). Churchill et al. [5] however reported a maximum temperature average of 64.7 °C (range 48.2 -76.8 °C) in a cadaver study on cemented glenoids using infrared thermography. The temperature results of this study agree well with the other in vivo reports [2,3] in terms of maximum temperatures during cement curing. An incomplete cement mantle was also found and may account for the variations in temperature across the thermocouples. Difference in the thermal properties and the influence of blood flow in vivo may account for some of these differences compared to in vitro models. The thermal damage caused during the bone preparation is another factor to consider in the biological response. This study is limited in that the temperature measurements are site specific.

REFERENCES

** The Avenue Hospital, Melbourne, Australia